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OFFICE OF
COAL
RESEARCH &
TECHNOLOGY

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Introduction

The Alberta Office of Coal Research and Technology was established on January 20, 1984 by Ministerial Order under the Department of Energy and Natural Resources Act.

The purpose of the Office is to encourage the development and application of new technologies related to Alberta's coals to improve coal exploration, production and transportation, and increase coal use and marketability.

Appointed to the Office are R. Douglas McDonald as Chairman, and Michael A. Ward and Garnet T. Page as Members. T. David Brown represents Energy, Mines and Resources Canada as an observer and he participates in project reviews.

Initial funding of $20 million has been allocated from the Alberta/Canada Energy Resources Research Fund to provide financial support for research projects.

"A successful Alberta Coal Research Strategy depends on the wise collaboration of government, industry and the research community"

CHAIRMAN'S REPORT

The Alberta Office of Coal Research and Technology has completed its second year of activities. During this period, the Office continued to develop an understanding with the Alberta coal industry regarding its role and responsibilities as outlined in the Alberta Coal Research Strategic Plan. A total of 45 research projects were supported during 1985/86. Research funding contributions by the Office totalled $2 862 874 during 1985/86, whereas contributions by industry and other groups totalled $2 983 000, representing 51 per cent of the total research expenditures.

A major initiative during the 1985/86 fiscal year was the joint planning of an industry/government coal combustion and utilization research program, from which several new projects directly related to industry needs are expected to result in enhanced markets for Alberta and other western Canadian coals.

A second focus for industry/government collaboration has been the application of improved geophysical techniques to assist in mine planning and result in reduced mine development costs.

Agreement was reached with the Alberta Research Council regarding future funding of coal research projects. This agreement reflects a reduced emphasis on the application of coal liquefaction technology and the continuing importance of conventional coal uses. The agreement also recognizes the importance of having stronger linkages between the Alberta Research Council and the private sector.

The Alberta Office of Coal Research and Technology worked closely with the Coal Mining Research Company (CMRC) during its period of restructuring. The Office has agreed to a three-year funding plan, beginning in 1985/86, which put increasing emphasis on the importance of industrial funding support for CMRC.

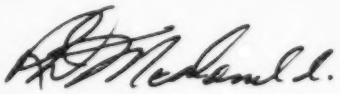
In addition to continuing its support for fundamental research through its Coal Research Grants Program, the Office has recognized the importance of establishing an effective program for transfer of technology to the coal industry.

The Office continued to receive secretariat support from the staff of Alberta Energy and Natural Resources, Scientific and Engineering Services and Research Division under the direction of P.F. Ziemkiewicz, as well as assistance from the Coal Research Technical Panel, the Interdepartmental Group for Coal Research and The Coal Association of Canada.

Effective May 1985, Dr. M.A. Ward was appointed to replace Dr. K.E. Cooper as a Member of the Office. Dr. Cooper's insight and assistance during the first 16 months of the Office's existence were most appreciated.

The Alberta coal industry continues to face a difficult situation with its markets. While the application of new technology can help to overcome these difficulties, it must be recognized that bold action will be required by individual companies and the government to realize the full potential of coal-related research and development.

The Alberta Office of Coal Research and Technology remains committed to encouraging concerted action within Alberta's coal industry and the coal research community to ensure the development and application of new technology, which will enhance the competitiveness of Alberta coals in the international coal market-place.



R. Douglas McDonald
Chairman

BACKGROUND

Alberta's coal industry provided an important energy source during the early development of the province and it continued to contribute significant economic activity until about 1950 when the coal market collapsed. In the mid-1960s, a resurgence occurred in the export market for metallurgical coal and in the provincial market for thermal coal. By 1974, annual production had risen to 9.5 million tonnes, with a gross market value of $985 million, of which approximately 35 per cent was derived from export markets.

From 1975 to 1985, Alberta's coal production rose from 10.1 million to 24.7 million tonnes, an increase of 146 per cent. During the same period, consumption of bituminous and subbituminous coals in Alberta rose from 5.4 million tonnes in 1975 to 18.1 million tonnes in 1985, an increase of 235 per cent.

Concurrently, the value of coal rose significantly. In 1975, 4.1 million tonnes of bitminous coal sold for $159 million, while 6.0 million tonnes of subbituminous coal were valued at $24 million. In 1985, 7.8 million tonnes of bituminous coal, almost all of which was exported, sold for $331 million and the industry received another $146 million for 16.9 million tonnes of subbituminous coal.

In 1985 alone, production was up seven per cent over 1984, comprising an additional 1.5 million tonnes of subbituminous coal and 211 000 tonnes of bituminous coal. The increase in subbituminous coal production reflects growing demand by Alberta utilities, which currently use coal to provide almost 91 per cent of Alberta's electric power generation.

These statistics underline some of the benefits and importance of Alberta's coal industry, but there are other advantages to having a healthy coal industry in the province. For example, coal mines provide a very high economic and social return on the land used. Also, the sale of coal to other countries improves Canada's trade balance, contributes to expansion of the provincial transportation network and fosters growth in the provincial construction industry during periods of expansion. Direct benefits include employment, financial contributions to the three levels of government and the purchase of goods and services within Alberta.

In the future, it is expected that Alberta's coal industry will continue to encourage the growth of secondary industries, provide a reliable and economic energy source for the recovery of the province's heavy oils and bitumen, and make other significant contributions to the province's economic base.

But, to optimize these benefits, coal exporting companies must first deal with certain realities such as the present oversupply of coal in the world. This competitive environment is further exacerbated by economic conditions in Japan, Canada's largest single coal export market, where demand for metallurgical coal, and the price that customers are willing to pay, have dropped sharply. Other markets for coking coal are undergoing similar changes.

The same can be said for exports of thermal coal. Offshore markets are not developing significantly because of lower electricity demand and falling oil prices on the international market. Also, Ontario Hydro, the largest Canadian customer outside the province for Alberta thermal coal, is expected to reduce its coal requirements until 1992 at the earliest.

Today's difficult market conditions make it essential that Alberta coal producers use the most efficient and most economical technologies in coal exploration, production, preparation, upgrading and transportation. Increasingly, overseas customers are demanding coal and coal products that possess specific qualities and behavior. To satisfy these requirements, coal producers must know more about the combustion characteristics of their products and be involved in the development of new technologies such as agglomeration, coal water fuels and other upgrading processes to produce coal products tailored to market requirements.

The Alberta coal industry's response to these difficulties and challenges is expressed in the Alberta Coal Research Strategy, published in November 1983, which evolved from extensive discussions among individual companies and the provincial government. Since then, the Office of Coal Research and Technology was established and subsequent industry proposals have resulted in jointly funded research and development projects. Additional support, designed to foster fundamental research of benefit to the coal industry, is provided by the Office of Coal Research and Technology's Coal Research Grants Program.

COAL RESEARCH STRATEGY

Research Rationale

Consistent with the views of the Government of Alberta, the Alberta Office of Coal Research and Technology believes the private sector should take the lead in identifying and managing appropriate research and development programs, as well as implementing and commercializing the results. The role of the Office and other government agencies such as the Alberta Research Council, along with universities and research organizations such as the Coal Mining Research Company, is to support the private sector to whatever extent is necessary to achieve the desired technical results in the most efficient manner.

While recognizing the need for longer term research and development, as well as fundamental research related to a better understanding of coal properties and uses, the critical time for commercial expansion and economic development of the province's coal resources is the intermediate time period from 1988 to 1998. During this time, major growth in thermal coal use throughout the world is projected, and increased competition can be expected from other coal-exporting countries. Other energy supplies, particularly natural gas and nuclear power, and the relative social and environmental acceptance of coal will have a major impact on the total thermal coal demand during this period.

New initiatives are required now, to ensure that Alberta coal achieves a maximum economic impact during the next 15 years. Toward this end, the Alberta Office of Coal Research and Technology, through the Alberta/Canada Energy Resources Research Fund, has identified initial funding of approximately $20 million in support of agreed research, development or demonstration projects. It is anticipated that similar funding will be forthcoming from the private sector in support of this strategy. Some portion of the funding will be identified for longer term or fundamental research directed toward new and innovative technologies related to the production and use of Alberta coals.

Alberta must collaborate closely with research groups in other provinces and countries to ensure that maximum benefit is derived from the total international coal research and development efforts, and to define its intermediate- and long-term plans within this context.

In pursuing its objectives, the Alberta Office of Coal Research and Technology works closely with The Coal Association of Canada to establish research and development priorities, and the Office collaborates with The Consulting Engineers of Alberta to develop and maintain a list of engineering skills available for coal research, development and project work in the province. In addition, the Office maintains world-wide contacts with persons engaged in coal-related research.

Administrative Framework

The Alberta Office of Coal Research and Technology does not have in-house facilities to carry out research projects. Rather, procedures have been established to ensure sound project management by the applicants and financial control of approved projects. Specific agreements are signed for each project which define the terms and conditions under which the project will be conducted and funded. These agreements also define the respective rights of project technology ownership and use.

The procedure to review and approve research proposals ensures that each proposal receives thorough consideration and a prompt response. Proposals considered to fall within the Alberta Coal Research Strategic Plan are discussed in detail with the applicant and are often referred in confidence to one or more outside experts for detailed technical review.

The President of The Coal Association of Canada also reviews a summary of each proposal on a confidential basis and provides his personal views on implications for the coal industry.

An Alberta government interdepartmental group has been established to comment on the implications of the proposed research within its areas of responsibility. This Interdepartmental Group for Coal Research includes respresentatives from the Energy Resources Conservation Board, Energy and Natural Resources (Alberta Forest Service, Public Lands and Fish and Wildlife divisions), Economic Development, Environment and Workers' Health, Safety and Compensation

Approval of the research proposals by the Members of the Alberta Office of Coal Research and Technology is based on the results of these reviews, the relative funding contributions and the likelihood that the proposed research will contribute to achieving the goals of the Alberta Coal Research Strategic Plan. Those projects funded within the Alberta/Canada Energy Resources Research Fund are subsequently submitted to that Committee for approval.

Applications received within the scope of the Alberta Coal Research Grants Program are reviewed by the Alberta Office of Coal Research and Technology to ensure they are consistent with the objectives of this program. Applications are then considered in detail by the Coal Technical Review Panel, which makes recommendations to the Office regarding the merits of each application and its associated funding and the extent to which it should be supported by the Office.

Research Program

The research program undertaken by the Alberta Office of Coal Research and Technology is guided by the Alberta Coal Research Strategy, the objectives of which are to ensure that the necessary coal-related technologies are available in a timely manner to permit realization of the full economic potential of Alberta's coal deposits through co-operation among the private sector, the research community and government.

Technologies that are likely to be commercially important during the period 1988 to 1998 will be identified, investigated and developed to:

- enhance the competitiveness of Alberta coals in international markets
- minimize the environmental impact from production or utilization of coal in Alberta
- generate new uses for Alberta coals.

Based on discussions with industry and the research community, the following research and development program areas have been identified as opportunities for further investigation. They are:

- Exploration
- Mining
- Preparation and Upgrading
- Combustion
- Conversion
- Transportation
- Environmental Protection
- Market Development

In each of these research areas, projects that are initiated must include due consideration of worker health and safety aspects, during both the research stage and subsequent commercial-scale applications.

The following section describes the issues and obstacles associated with each program area and summarizes the status of those research projects which received funding from the Alberta Office of Coal Research and Technology in 1985/86.

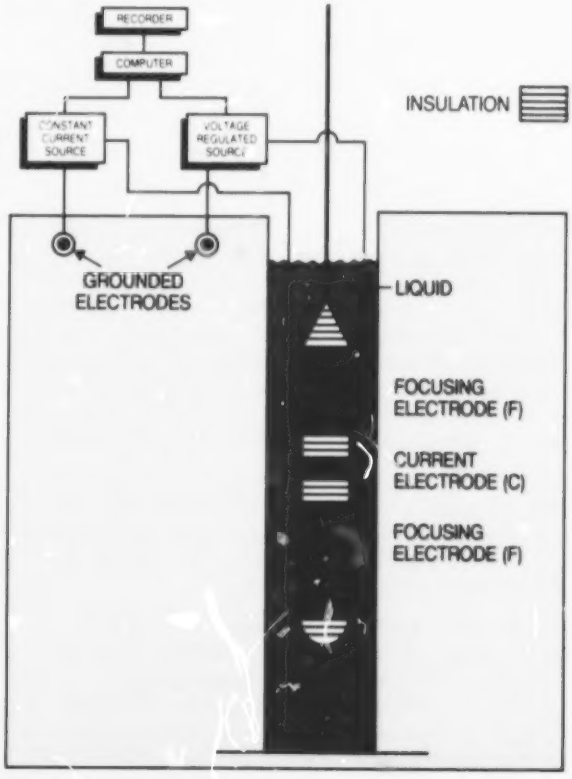
EXPLORATION

The need exists for improved cost-effective geophysical exploration methods which assist in the identification of subcrops and the extent of coal reserves as well as permit the in situ characterization of coal. Such information as can be provided by these techniques is important for purposes of mine planning. Also, the coal industry needs to know more about the stability of overburden materials and their mining characteristics.

Potential of Geophysical Techniques for Coal Exploration

COAL MINING RESEARCH COMPANY, DEVON

This one-year study identified a need within Alberta's coal industry for techniques that can be used to locate and delineate coal deposits with a greater degree of accuracy. A need also exists for inexpensive methods to characterize coal deposits without excavation or coring.



Focused resistivity is a promising method of geophysical instrumentation, which might be developed for purposes of coal exploration.

The authors of the study recommended that geophysical research in progress in the plains region be extended to the mountains and foothills, that surface electrical methods be further developed for coal exploration and that borehole geophysical methods be developed for in situ coal characterization.

The authors also recommended an integrated technology transfer plan be devised to provide the coal industry with ready access to information regarding geophysical methods.

Surface Geophysical Coal Exploration

TRANSALTA UTILITIES CORPORATION, CALGARY, AND OTHER PARTICIPANTS

The potential of various geophysical exploration techniques for subcrop definition is being investigated for their ability to differentiate among till, bedrock and subsurface horizons. This information is required by mining companies to assist in mine planning while reducing the cost of conventional drilling programs.

The geophysical methods being evaluated are: reflection and refraction seismology, direct current resistivity, and electro-magnetic conduction.

The project is in the second year of a planned three-year program. At Genessee, the coal subcrop was successfully mapped by reflection seismology. Washouts and glaciotectonic discontinuities in the coal bed were most easily located by refraction seismology. Material properties in situ were derived from direct current resistivity and electromagnetic field data. At the Paintearth Mine, anomalies observed during the 1984 field program were confirmed as having been glacially disturbed by infill drilling. Subcrop characteristics predicted by geophysics were also confirmed by drilling. Further development of the data analysis and interpretation techniques is planned for 1986/87. Also, the use and development of new seismic energy sources and equipment will be evaluated for possible application to short-, medium- and long-term mine planning.

Measurements of the resistance of the ground to direct electrical current are used to define the location of coal subcrops.

Very Low Frequency Geophysical Methods in Coal Exploration

SMOKY RIVER COAL LIMITED, GRANDE CACHE

The geophysical technique used in this project makes use of very low frequency, high power signals from transmitting stations used for aviation and marine navigation. The signals from two U.S. stations were used to generate two sets of primary magnetic field lines at approximately right angles to each other. The primary magnetic field induced eddy currents in conductive rock formations which, in turn, produced a very low frequency electromagnetic secondary magnetic field. Results of the project indicate that techniques have limited use in mountain coal exploration, but can be used for geological mapping in conjunction with outcrop mapping and drilling data. Depending upon weathering conditions or the presence of ground water, coal seams cannot be identified in all cases. The relationship between survey lines and geological conditions must be known to identify the responses.

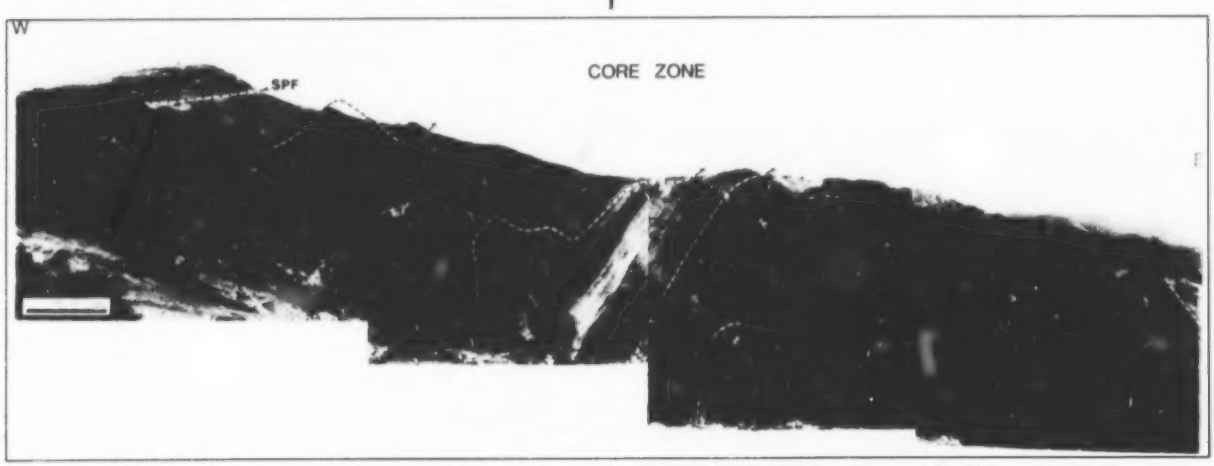
Structural Geometry of Imbricated Thrust Sheets

UNIVERSITY OF CALGARY, (D.A. SPRATT), CALGARY

A comparative study is being made of the three-dimensional geometries of three well-exposed areas of imbricate thrusting in Jurassic-Cretaceous strata of the Highwood and Oldman basins in southwestern Alberta. The objective is to recognize and delineate structures common to all areas, as well as structures that have developed only in particular structural settings. The resulting classification of three-dimensional Jurassic-Cretaceous structures, as indicated by their outcrop patterns, should be applicable throughout the fold and thrust belt. It should lead to lower costs during early stages of coal exploration in this and other thrust belts by providing the ability to identify shallow reserves by the surface geometry of the overlying strata.

The three completely deformed coal-bearing regions are being geologically mapped in detail by geological field parties. The resulting data are then analyzed statistically and geometrically.

1985/86 represented the first year of a two-year program. Three thousand man-hours were devoted to geologic mapping and the acquisition of field data and samples. An atypical geologic structure was discovered during the course of the field work. It is expected that these new findings will significantly alter previous interpretations of the entire region.



Analysis of the Livingstone Thrust Plate (shown here) reveals the complex structural environment in which coal is found.

MINING

For Alberta's coal producers to remain competitive in the future, new mining and materials handling techniques will be required for surface operations during the next five to 15 years.

For example, one way to reduce mining costs is to make highwalls steeper. This lowers the costs of removing overburden, but if the highwall becomes too steep a failure can result, endangering workers and equipment. Consideration of aspects such as these is the focus of some projects in this program area.

Also, some researchers have begun to look beyond the turn of the century and predict the nature and needs of Alberta's coal industry to the year 2035.

Geotechnical Properties of Overburden

COAL MINING RESEARCH COMPANY, DEVON

This project allowed CMRC staff to acquire the capability and skills for measuring the geotechnical and physical characteristics of overburden materials using newly acquired instruments and provided for the installation and commissioning of test equipment.

A computer-controlled Instron load frame was installed in the rock mechanics laboratory, providing the capability to conduct large-diameter, high-load sample testing up to one million pounds force.

Soil mechanics testing equipment, capable of unconfined compression, shear strength, triaxial strength and consolidation testing was delivered and commissioned, providing full geotechnical research capabilities for unconsolidated overburden.

The Subsidence Handbook has been completed and published by the Coal Mining Research Company, with contributions from Norwest Consultants, CANMET, Associated Mining Consultants Ltd. and the National Coal Board.

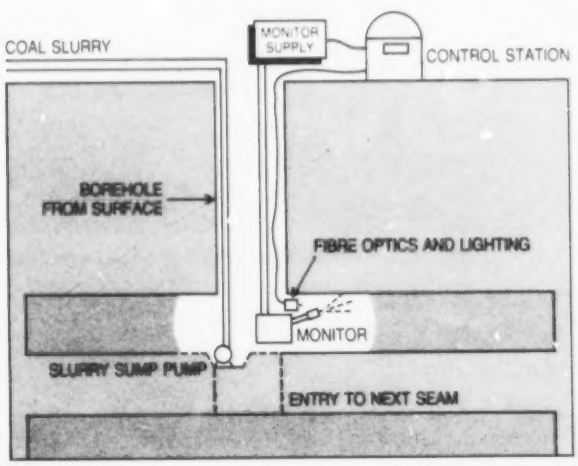
The handbook contains a technical discussion of coal mine subsidence mechanisms, methods for prediction of subsidence, methods for ground deformation monitoring using both conventional optical land survey techniques and electronic tiltmeters, and mitigative measures for the protection of surface works. Case histories from the United Kingdom, Australia and the United States are included in the text.

Coal Mining In 2035

COAL MINING RESEARCH COMPANY, DEVON

The nature of coal mining in Alberta, and production technologies likely to be used by the industry over the next 50 years, were the subjects of this investigation. The following conclusions were reached:

- to meet future demands, coal production is forecast to exceed 80 million tonnes a year in 2010 and to be approximately 200 million tonnes a year in 2035, provided that coal continues to be used as the primary fuel for electric power generation and there is continued growth in the export demand for bituminous thermal coal.
- while strip ratios and overburden thicknesses will increase over the next 50 years, mining conditions will not be substantially different from those in 1986.
- surface mining will continue to be the principal coal mining method in Alberta for the next 25 years, and probably beyond, although underground mining will be considered where appropriate. After 2010, there is likely to be an increase in underground mining.
- the review of current and emerging technologies shows that some developments and techniques which are already available have yet to be adopted by the coal industry.
- mining concepts are not likely to change substantially over the next 25 years but innovations such as automation, remote control and widespread use of sensors and computer-based techniques will contribute to the efficiency, productivity and safety of all aspects of coal mining.



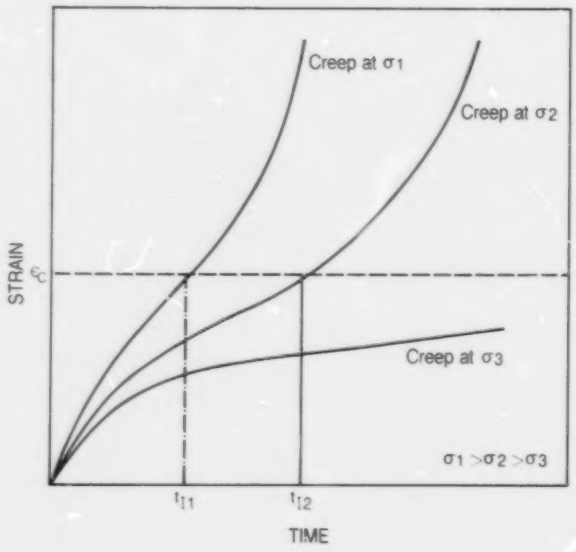
Looking ahead to the 21st century, it is possible that underground mining in Alberta will be performed by equipment that is remotely controlled from the surface.

Ground Movements In Coal Mines

UNIVERSITY OF ALBERTA, (D.M. CRUDEN), EDMONTON

Recent instrumentation advances have provided the technology for monitoring ground movements on a routine basis. Interpretation of the movement being monitored, however, has not reached the same degree of sophistication.

This project applies ground movement models, successfully developed for monitoring landslides, to problems found in coal mining. A conceptual model of the time-dependent loss of strength of coal has been developed, and attention is being turned to development of the deformation-dependent model by rewriting the time-dependent model. Laboratory data support has been generated by measuring shear resistance decrease with displacement of a rock sample on a specially designed tilting table.



Continuing activities will include the development of parameters for these models by means of a new technique involving the evaluation of the time-dependent behavior in laboratory tests of coal samples. Innovations will be built into existing software for processing observations from creep experiments and measurement of ground displacements.

From creep experiments, and displacement records at an Alberta coal mine, it was shown that ground movement can be accurately described by the following equation:

$$de/dt = At^B + Ct^D$$

de/dt is displacement rate

A,B,C,D are constants

t is elapsed time

Coal Mining Research

COAL MINING RESEARCH COMPANY, DEVON

Several important first-phase projects were begun this year. Laboratories for future rock and soil mechanics research were commissioned. An initial study on the applications of geophysics to coal exploration in Alberta and a preliminary assessment of the applications of advanced technology to coal mining were completed in preparation for specific research projects to follow.

PREPARATION AND UPGRADING

Because mined coal may contain from five to 25 per cent moisture and 15 to 20 per cent ash, preparation processes are required to reduce the amount of these non-combustibles and improve the energy content, combustion characteristics and sulphur content of coal to make it more attractive in competitive markets. Lately there has been a growing interest in upgrading bituminous and subbituminous coals for export to enhance their energy content and performance characteristics. For these reasons, several research projects supported by the Alberta Office of Coal Research and Technology are attempting to provide better coal preparation and upgrading methods.

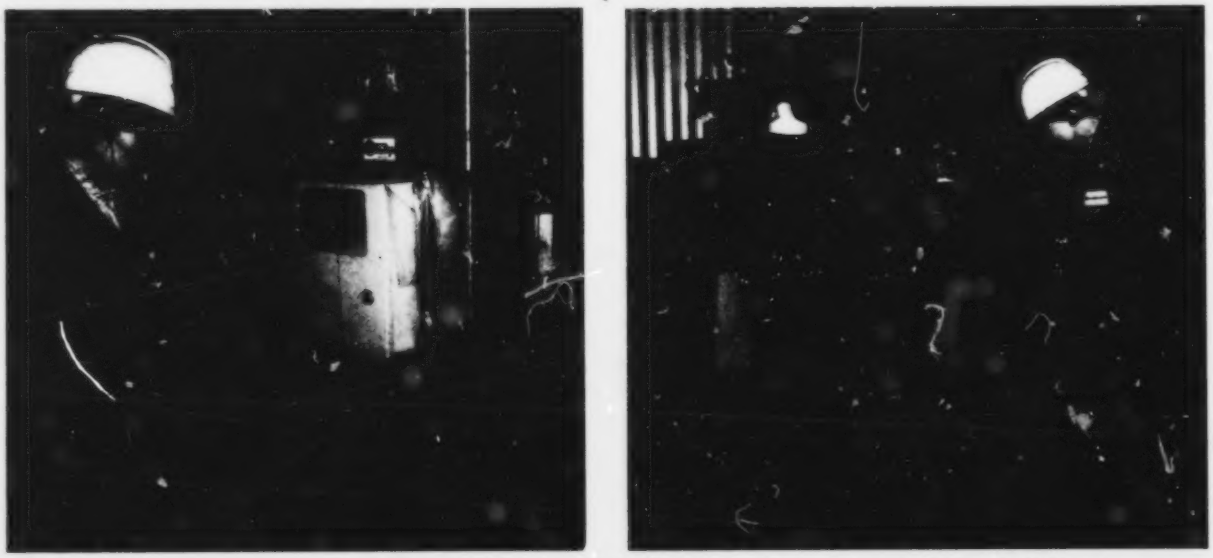
Properties of Thermally Dried Coals

COAL MINING RESEARCH COMPANY, DEVON

Because western Canadian coals must be dried to reduce their moisture content to required specifications, the objective of this project was to develop techniques and equipment to assess certain properties of thermally dried coal. They included chemical and physical properties of low moisture content coal products, moisture readsorption, stability (susceptibility to spontaneous combustion), flow characteristics and dustiness.

Work completed included conversion of a bench-scale, batch Roto-Louvre dryer to accommodate a continuous flow fluidized bed unit. The objective was to establish improvements in coal drying technology which may lead to a more cost-effective thermal dryer suited to the fluctuating quality, high fines and high moisture content characteristics of western Canadian coals. A test program was carried out for both sets of equipment. However, problems with the main pilot plant dust extraction system interrupted the program before completion. It will be pursued next fiscal year.

An experimental program to obtain CO_2 adsorption data was completed at the bench scale, as was an experimental program on the ASTM-type Dustiness Cabinet apparatus.



The ASTM Dustiness test cabinet (left) and the Durham Cone apparatus (right) were used in assessments of thermally dried coal properties.

Coal Preparation Research

COAL MINING RESEARCH COMPANY, DEVON

Several projects initiated in previous years were completed this year, and reports were prepared. They were:

1. Introduction to Coal Drying

An introductory publication was prepared for persons who need a basic knowledge and understanding of the process of coal drying. The kinds of moisture found in and on coals are described, as well as the reasons for artificially drying coal, the drying mechanism, the operating principles behind conventional dryers and dryer design criteria.

2. Thermal Drying of a Raw Western Canadian Low-Rank Coal

The drying characteristics of three commercially available coal dryers were evaluated. None of the units was found to be entirely satisfactory. Problems with the coal handling systems were also documented, as were potential uses for clays extracted from coal during drying.

3. Drying Characteristics of Western Canadian Coals

The relationship between coal rank and drying characteristics was investigated. A bench-scale procedure for the prediction of product moisture was devised and drying plant design criteria were developed. It was recommended that a series of studies on properties of thermally dried coal be undertaken to ascertain optimum conditions whereby thermal coals can be dried to less than their equilibrium moisture content.

4. Counter-Current Fluidized Bed Dry Cleaner

A pilot plant assessment was completed of one approach to coal cleaning technology which may be more cost-effective for high clay and high moisture content western Canadian coals.

5. Fine Coal Cleaning Process

A technology review was completed to seek processes to economically recover fine coal which would otherwise be lost in plant tailings.

6. Economic Evaluation of Alternative Preparation Schemes

An economic study was made of various methods that might be used to improve the calorific value of western Canadian coals to meet export specifications and to determine optimum combinations of preparation and upgrading processes which might be beneficial for particular operations.

Agglomeration of Subbituminous Coal

MANALTA COAL LTD., CALGARY

Coal agglomeration is a process whereby finely ground coal and a liquid hydrocarbon are mixed in a water slurry to produce a stable low-ash, low-moisture product with a high heat value.

The most efficient means of creating agglomerated coal products will be studied and these will form the basis for an economic feasibility study of agglomeration as a coal upgrading process.

Screening tests on two subbituminous coals were carried out by the Alberta Research Council in 1985/86. The economic feasibility assessment will be carried out by an independent contractor in the next fiscal year.

Preparation Process Yield Losses

COAL MINING RESEARCH COMPANY, DEVON

The objectives of the project were to: (1) assess the capabilities of numerical analysis techniques for evaluating historical preparation plant data and (2) determine whether ash fluctuations in a flotation feed affect the ash and yield of clean coal.

Based on a monitoring program within an operating coal preparation plant, the study concluded that ash fluctuations behave according to a fractal Brownian model of dimension less than two, with a period in the order of tens of minutes. Analysis showed that the sampling interval must be short in order to adequately track fluctuations in feed coal ash content using the model.

Coal Beneficiation Process

GULF CANADA CORPORATION, SHERIDAN PARK, ONTARIO

The objective of this project is to construct a mine-mouth demonstration plant and evaluate the economics of a particular process for upgrading Obed Mountain bituminous coal.

A patented Gulf treatment process was extensively tested on batch and continuous processing, bench-scale equipment built for this purpose. In the batch processing mode, coal immersion and recovery were successful; however, removal of residuum to below five per cent product weight was unsuccessful. An alternative simple beneficiation process employing oil injection was developed and successfully applied to Obed Mountain coal. Gulf Canada Corporation has applied for a patent for this successful technique.

COMBUSTION

One of coal's most important purposes is to be burned as a fuel in various types of combustion equipment to generate steam or produce heat. Because individual coal types behave differently when they burn, and some are better suited than others for particular requirements, it is important to understand the reasons for differences in combustion behavior and how these characteristics can be used to advantage by Alberta's coal industry.

During 1985/86, discussions were held with the coal industry to determine the scope of a co-operative research program in the field of coal combustion. Several research priorities and specific research projects were identified, as follows:

1. Combustion of Western Canadian Coals in Existing Boilers and Burners.
2. Combustion Technology Awareness Program
3. Gasification Characteristics of Western Canadian Coals
4. Dry Sorbent Injection for Sulphur Emission Reduction
5. Coal Utilization in Enhanced Oil Recovery

In addition, several other coal combustion projects were underway this year.

Smoky DENSECOAL Combustion Tests

MONENCO CONSULTANTS LTD., CALGARY

The potential for using coal water fuels as a substitute for heavy fuel oil in a variety of industrial and power generation applications is receiving worldwide interest. Salzgitter Industriebau GmbH, Federal Republic of Germany, had previously tested several Canadian coals for compatibility with their DENSECOAL process. A low volatile coal from the mountain region of Alberta was found to be particularly suited to this process. However, concerns were expressed regarding the combustibility of coal water fuels made from low volatile high rank coals. This test, using a DUMAG pilot burner, was undertaken to provide an initial indication of the combustibility of this fuel. Monenco Consultants Ltd. was contracted to observe the test and to comment on the relevance of the test to commercial applications of coal water fuels.

While the test burner was not extensively instrumented, the results indicated that the coal water fuel could be burned in an unsupported flame, provided the furnace zone was preheated to temperatures above 1050°C.

The test also demonstrated that the sample used for the test was easily homogenized and stable after storage and transportation.

Prediction of Coal Combustibility

ESSO RESOURCES CANADA LIMITED, CALGARY

The system of coal classification recommended by the American Society for Testing and Materials (ASTM) uses certain geological properties to classify coals according to rank. These same properties are also widely used to guide the selection of coals for pulverized-fuel combustion. A more comprehensive approach is to include a complementary classification based on the thermal reactivity characteristics of coals under conditions which simulate pulverized-coal firing.

Experiments have been carried out to evaluate the relationships between pyrolysis and combustion behavior and detailed properties of test coals. Using vitrinites, a maceral common to most coals, strong correlations have been identified between certain key combustion characteristics and feedstock properties. The application of these results to coals containing more complex mixtures of various macerals has given encouraging preliminary results.

The test data suggest that it may be possible to produce predictive ratings of the combustibility of coal reserves using small samples such as are collected for routine coal quality data. The method should be most relevant to high-rank bituminous foothills and mountain coals of Alberta.

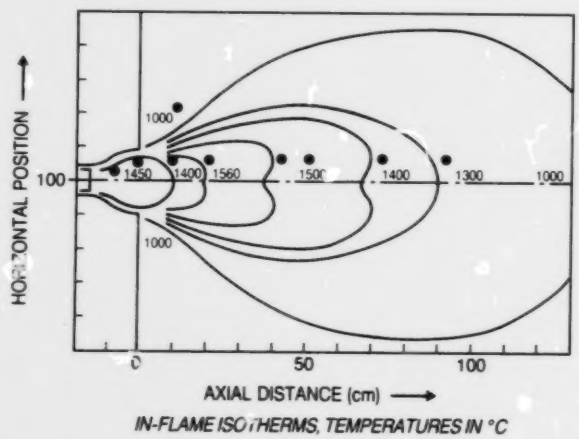
Reflectance microscopy investigations of coals have established correlations among vitrinite content and key combustion characteristics.

International Energy Agency Coal Combustion Science

NETHERLANDS ENERGY RESEARCH FOUNDATION, PETTEN

This international research program, under the auspices of the International Energy Agency, is investigating novel techniques to reduce gaseous and particulate emissions as well as studying the behavior of coal particles in combustion flames. As one of the Canadian contributors to the program, the Alberta Office of Coal Research and Technology will obtain information allowing comparison of the combustion characteristics of western Canadian coals with coals from other countries. Also, Alberta coals will be used to develop advanced, low NO_X burners.

The project, which is in the first year of a planned three-year program, includes studies of coal characterization, internally air-staged and fuel-staged burner development, investigations of dry sorbent injection for sulphur emission reduction and measurements of mineral matter transformations in combustion environments. Testing of several coals, including Highvale subbituminous coal, was completed in the coal characterization project. Two promising internally air-staged burners were selected for further development work. Operating parameters and sorbent characteristics affecting sulphur capture during dry sorbent injection were defined. A literature review of mineral matter transformations in coal flames was completed.



A typical temperature profile in the International Flame Research Foundation semi-industrial furnace used in the IEA coal combustion study.

Combustion of Agglomerated Coal

SCIENTIFIC AND ENGINEERING SERVICES & RESEARCH DIVISION, ALBERTA ENERGY AND NATURAL RESOURCES, EDMONTON, AND LUSCAR LTD., EDMONTON

The burning characteristics of various agglomerated coals are being evaluated, and analyses are to be made of the effluent gases and solids.

When a sample of Alberta subbituminous coal agglomerates was burned at Ontario Hydro's coal combustion research facility, preliminary results showed that the coal had a high heating value and good burning characteristics.

Combustion Process Research

ALBERTA RESEARCH COUNCIL, DEVON

The objective of this project is to train Alberta Research Council personnel regarding the nature and extent of combustion research in progress.

Visits were made to the University of North Dakota Energy Research Centre, Sandia National Laboratory and the Pittsburgh Energy Technology Centre. Agreements to permit Alberta Research Council staff to work in these laboratories were under negotiation at year's end. Temporary placement of staff in other laboratories is expected early in the next fiscal year.

Combustion Characteristics of Alberta Coals

ALBERTA RESEARCH COUNCIL, DEVON

In support of Alberta exports of thermal coals, an understanding of the combustion properties of Alberta coals is required.

A technique to separate coal macerals was developed, and methods for determining particle surface structure were assessed. Some initial theoretical work to relate surface structure to combustion properties was begun.

An intrain flow combustor (top) and a thermogravimetric analyzer (bottom) were used to gain a better understanding of the combustion characteristics of Alberta coals.

CONVERSION

Conversion of coal into liquid fuels is an important option for Alberta's coal industry. Already, research studies have indicated that the co-processing of coal and heavy oil or bitumen offers sufficient economic benefits to justify continued investigations. Given the uncertainty of future oil prices and the importance of heavy oil and oil sands to Alberta's economy, the development of improved technologies for the upgrading of these resources must be encouraged.

Liquefaction Process Improvements

ALBERTA RESEARCH COUNCIL, NISKU

Co-processing of subbituminous coals with heavy oil or bitumen to produce lighter hydrocarbon liquids suitable for refinery feedstocks has been investigated at the Alberta Research Council for several years with promising results. In comparison to direct liquefaction, the two-stage co-processing mode significantly reduces the costs of producing liquid fuels from coal. Nevertheless, further evolutionary process improvements are required to enhance the cost competitiveness of coal-derived liquids.

Technical alternatives which have been identified include:

- use of supported catalysts to enhance coal solubilization in the first stage.
- use of reducing gas rich in H_2S or syngas mixture during solubilization
- pretreatment of heavy oil to enhance hydrogen-donating characteristics
- use of hydropyrolysis or fluid coking for raw liquid upgrading in the second stage

The potential of these alternatives is being considered.

Liquefaction Process Evaluation

ALBERTA RESEARCH COUNCIL, NISKU

Simple techniques are required to evaluate the relative technical and economic merits of proposed new liquefaction processes. A preliminary review of previous economic evaluations and a strategy for developing simple techniques were completed. Mass and energy balances were attempted for a generic commercial liquefaction process based on published flowsheets and physical property data.

ENR/ARC Coal Conversion Research Program

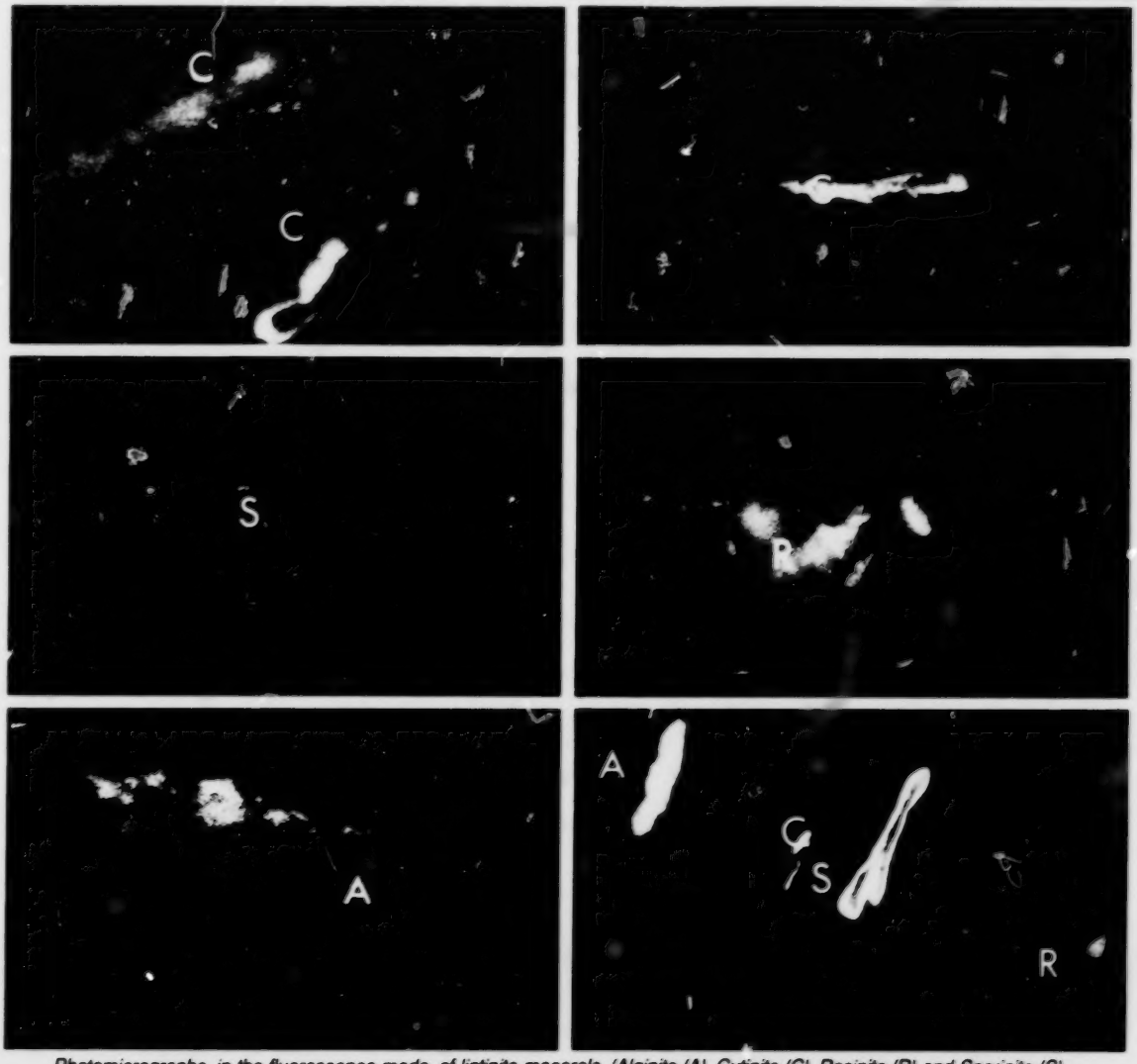
ALBERTA RESEARCH COUNCIL, DEVON

This five-year program investigated the potential of three different approaches to convert Alberta subbituminous coals into liquid hydrocarbon products. These are: partial conversion by pyrolysis and hydropyrolysis, and complete conversion by direct liquefaction or co-processing of coal with heavy oil or bitumen.

Pyrolysis results showed that all Alberta subbituminous coals have similar liquid yields. Hydropyrolysis of subbituminous coal yielded eight per cent benzene and a char which may be suitable as a fuel in a utility boiler.

For complete conversion of coal to liquids, co-processing of coal with heavy oil or bitumen offers the greatest potential for the production of feedstocks that can be used to make liquid transportation fuels. Data showed that the Paskapoo coals of Alberta appear to be somewhat less reactive than Horseshoe Canyon coals. Hence, they require more severe process conditions.

Supporting investigations included chemical characterization and maceral studies.



Photomicrographs, in the fluorescence mode, of liptinite macerals. (Alginite (A), Cutinite (C), Resinite (R) and Sporinite (S).

PYROSOL Process Review

CANADIAN UTILITIES LTD. AND LUSCAR LTD., EDMONTON

A previous study carried out in co-operation with Contar Systems Engineering Ltd., Edmonton, and severa' other companies, indicated that the process economics associated with the co-processing of coal and heavy oil into liquid fuels is comparable to heavy oil upgrading. During the earlier study, it was learned that the PYROSOL process proposed by Gesellschaft fuer Kohleverfluessigung mbH, Federal Republic of Germany, was said to offer economic advantages. Princeton Process Engineers was commissioned to assess the technical claims associated with the PYROSOL process and to define the technical risks.

On the basis of this review, a laboratory bench-scale program was recommended to assess certain technical areas and to provide the data necessary to allow the design of a larger-scale process development unit.

Chemistry of Coal Liquefaction

ALBERTA RESEARCH COUNCIL, DEVON

Most published coal liquefaction or co-processing evaluations do not satisfactorily describe product quality. Also, they do not explain the chemical changes that occur in process fluids at each processing step. As a first step in providing this information and establishing a scientific basis for future work, an analysis tree has been developed and specific tests for important compounds in bitumen are being studied. A parallel testing sequence will be carried out for solubilized coal. A series of laboratory-scale experiments will be conducted on co-processed liquids to identify reaction pathways, the results of which will be used in the Process Improvements Project. The liquid characterization protocols are expected to be suitable for monitoring the quality of process fluids at various steps of liquefaction processes.

Functional Group Analysis of Coal Liquids

UNIVERSITY OF ALBERTA, (M.R. GRAY), EDMONTON

This is the first year of a two-year program to develop methods for structural analysis of coal liquids. This should aid in the development of new technologies for coal conversion.

Important coal conversion processes were identified, coal liquid samples were obtained and development of analytical methods specific to coal liquids was carried out.

Computer software was developed to combine analytical data from spectroscopic analysis of coal liquids with the elemental composition, and to calculate the concentrations of important chemical structures. Liquid samples from hydropyrolysis and catalytic liquefaction were used to check the structural analysis.

Solvent extraction techniques were used in a laboratory study of coal liquid functional groups.

New Liquefaction Processes

ALBERTA RESEARCH COUNCIL, NISKU

Most of the processes used to convert coal to synthetic crude petroleum involve high temperature and pressure. These "high severity" processes consume large amounts of energy and demand large capital investment in the physical plant.

This project, however, is attempting to identify revolutionary physical and chemical processes that will permit conversion of coal to petroleum-like substances under low severity conditions.

A literature review revealed several promising concepts which were evaluated for possible application to Alberta subbituminous coals. Two types of low severity processes merit further work. They are: (1) those supplying large amounts of hydrogen during a thermal liquefaction stage and (2) those concentrating on chemical depolymerization of the coal structure, followed by secondary upgrading and hydrogen addition to the resulting fluid.

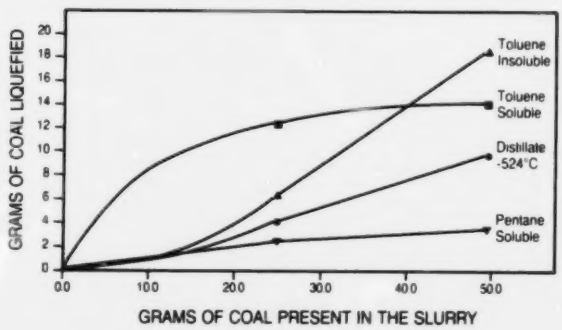
Isotopic Studies of Co-processing Liquids

UNIVERSITY OF ALBERTA, (K. MUEHLENBACHS), EDMONTON

In coal-bitumen co-processing schemes a synthetic oil can be readily produced. However, process refinement should be facilitated if the relative contributions of the coal and the bitumen can be ascertained.

In this study, a method was developed to quantitatively determine the amount of coal incorporated into the synthetic oil, using isotope mass balance.

Products from the Alberta Research Council two-stage coal-bitumen co-processing scheme for the production of refinery grade synthetic oil have been analyzed. It was found that 14 to 23 per cent of the carbon in the oil is coal derived.



The amount of carbon that is derived from coal, when bitumen and coal are co-processed to form a synthetic oil, was determined by isotope mass balance analyses.

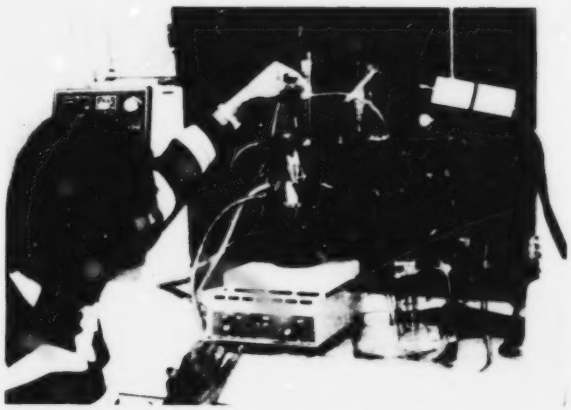
Electrolysis of Coal Slurries

UNIVERSITY OF CALGARY, (V.I. BIRSS), CALGARY

Hydrogen production can be accomplished electrochemically by the electrolysis of water, with concurrent oxygen evolution, primarily from alkaline solutions. Theoretical thermodynamic potentials indicate that very significant energy savings can be realized by replacing alkaline electrolytes with acidic coal slurries.

The primary objective of this research program is to test the feasibility of electrolysis of slurries of various grades of Alberta coal, while a secondary objective is to determine the achievable rates of hydrogen production as a function of time and of applied voltage. Other variables will also be investigated in order to determine the optimum reaction conditions.

Electrolysis experiments have been carried out at room temperature and current efforts are directed toward coal slurry electrolysis at higher temperatures, for example 90°C, which yield a higher reaction rate. The gaseous products produced at the anode are being analyzed by means of gas chromatography.



Electrolysis studies at the University of Calgary are attempting to recover valuable hydrocarbon products from aqueous slurries of Alberta coals.

ENVIRONMENT

Environmental protection is becoming an increasingly important factor associated with economic development in Alberta. As a consequence, the coal industry is attempting to reduce or eliminate the need for tailings ponds and provide proper treatment of wastewaters. Also, mining companies are participating with government (through the Alberta Reclamation Research Program) in land reclamation projects to reclaim mined areas for other purposes after mining has ceased.

Coal Conversion Wastewater Treatment Technology

UNIVERSITY OF ALBERTA, (S.E. HRUDEY), EDMONTON

Anaerobic biological methods used to treat other types of liquid waste might be used to treat coal conversion wastewater, but the presence of certain chemicals in the waste stream can inhibit the process. During the first year of a two-year study, characterization studies were carried out to establish the organic composition of representative coal conversion wastewaters, of which phenolic compounds are a dominant fraction.

Preliminary screening experiments had previously used gas chromatography analysis, but results were found to be inconsistent. Consequently, a high pressure liquid chromatographic method for direct phenols analysis has been implemented. Excellent, stable performance has been established and consistent reproducible results are being achieved. The liquid chromatographic method has confirmed that the initial anaerobic experiments produced promising but inconsistent results.

Subsequently, suitable pH adjustments for solvent extraction were determined and a solvent extraction experiment established the phenolic partitioning. Another series of batch treatability experiments was run using solvent extraction at variable pH. The results are encouraging and suggest that treatment of full strength coal conversion wastewater following appropriately selected solvent extraction should be possible.

MARKETS

While the subject of market development is complex and is primarily the responsibility of industry, the Alberta Office of Coal Research and Technology believes that opportunities for which technological innnovation and development are required can be explored in collaboration with industry and potential customers.

Conversion from Oil to Coal Water Fuels (CWF)

SMOKY RIVER COAL LIMITED, GRANDE CACHE

The study reviewed the technical and economic aspects of converting the Corporation Dominica Electricidad's existing No. 6 fuel oil-fired Haina No. 1 Unit to fire Smoky River DENSECOAL while retaining its ability to fire No. 6 fuel oil either alternatively or simultaneously with DENSECOAL. The study also addressed the requirements for further testing of Smoky River DENSECOAL. The study concluded that:

- the proposed conversion is feasible.
- the unit will be derated to 60 per cent of its oil-fired maximum continuous rating (MCR) when firing Smoky River DENSECOAL.
- at this time, and without further detailed study by Combustion Engineering (the boiler manufacturer), there appears to be no reasonably simple method of altering the extent of derating when Smoky River DENSECOAL is used.
- the cost of the conversion is estimated to be approximately U.S. $6.9 million.
- the economic feasibility of the conversion, given the process economics of DENSECOAL, requires an international oil price of at least U.S. $26 barrel.

Fuel Options for Enhanced Oil Recovery

L.A. SMITH CONSULTING & DEVELOPMENT LTD., CALGARY

This multi-client study examined the effects on project economics of using various fuels as alternatives to natural gas for steam raising at five locations in Alberta. The economics for generating plants at Lindbergh, Cold Lake, Peace River, Central Athabasca and Northern Athabasca were developed by two methods: (1) a utility compensatory cost of generated steam and (2) a discounted cash flow (DCF) approach based on differential expenditures.

It was found that coal and petroleum coke can be delivered to steam generating facilities at significantly lower energy cost than natural gas, but higher capital and operating costs associated with the handling, transportation, combustion and cleanup of solid fuels has an offsetting effect. The crude oil production levels at which coal and coke provide steam of equivalent cost to that generated with natural gas are tabulated.

OTHER PROJECTS

Coal Technology Information Centre

ALBERTA RESEARCH COUNCIL, DEVON

The Coal Technology Information Centre was initiated in 1977 to collect and disseminate technical information related to coal. Since then, the Centre has provided a high standard of service in response to queries related to every aspect of coal technology.

During the same period, however, several international coal technology data bases were established from which information was readily available. Based on an independent review (by Crozier Information Resources Consulting Ltd.) of the Coal Technology Information Centre's activities, it was concluded that it would be increasingly difficult for the Centre to maintain a competitive quality of information without a major increase in financial support. Consequently, it was decided that funding by the Alberta Office of Coal Research and Technology would end as of March 31, 1986.

Devon Coal Research Centre

DEVON

The centre was officially opened on September 13, 1985 by the Hon. Robert E.J. Layton, Minister of State, Energy, Mines and Resources Canada and the Hon. Don Sparrow, Alberta Minister of Forestry. With its completion, the only expenditures required during 1985/86 were for site landscaping.

The merits of a world class coal research centre are becoming apparent. Many visitors from throughout the world have seen the Centre. Co-operation and co-ordination among the three research organizations, along with the capabilities and competence of their scientists, engineers and support staffs, will play an increasingly important role in the overall objectives of enhancing the competitiveness of Alberta coals.

Information for Research Planning

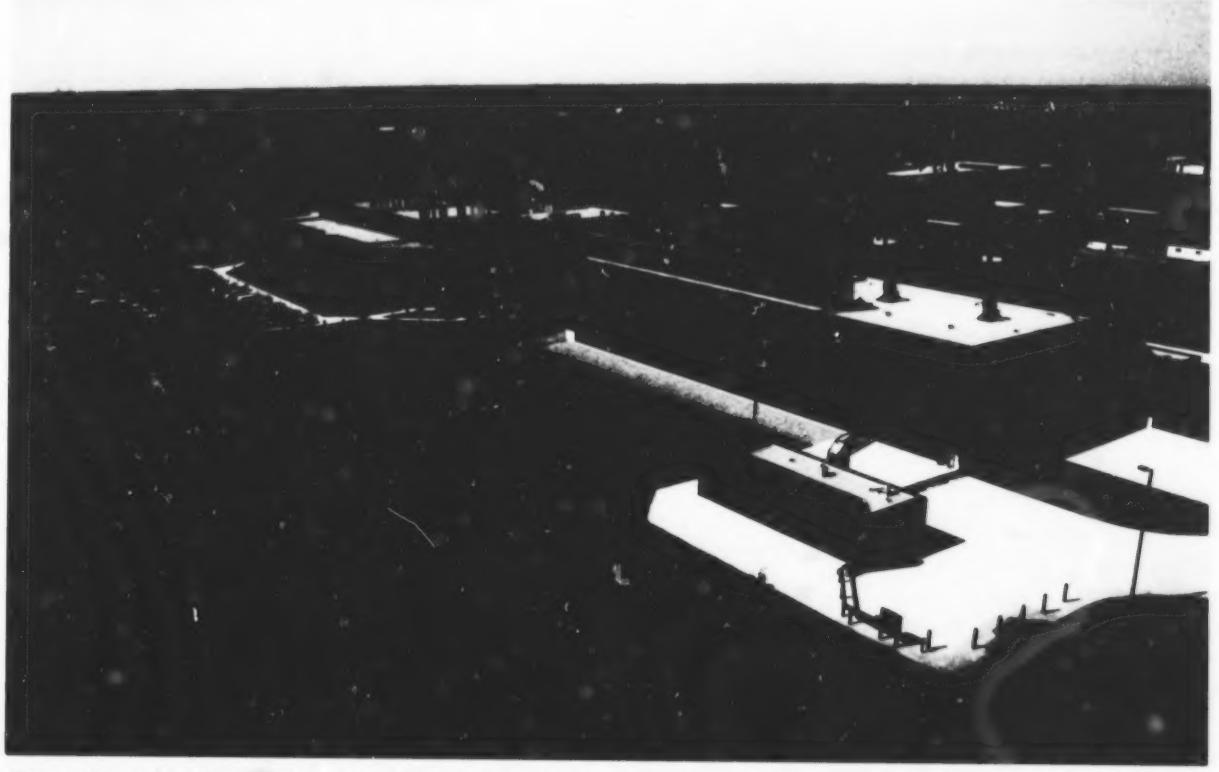
COAL MINING RESEARCH COMPANY DEVON

The principal objective of this project is to identify those research and development requirements of the coal mining industry which will have a significant impact on the future marketability and competitiveness of Canadian coal in local and overseas markets. This year, staff of the Coal Mining Research Company met with senior coal industry and government representatives and visited mine sites, plants and R & D facilities.

Technical Information Needs

CROZIER INFORMATION RESOURCES CONSULTING LTD., EDMONTON

Following the closure of the Coal Technology Information Centre, this study was initiated to establish the coal information requirements of the coal industry and the Alberta Office of Coal Research and Technology. Ready access to technical and market information was identified as the most critical requirement, and several sources of this information within Alberta were identified.



The new Devon Coal Research Centre is assisting the coal industry in developing new techniques related to the mining, marketing and future uses of coal.

Project Expenditures

During the fiscal year from April 1, 1985 to March 31, 1986, expenditures on approved research projects totalled $5 845 874 of which $2 862 874 was provided from the Alberta/Canada Energy Resources Research Fund. The remainder, $2 983 000, or 51 per cent of the total, was contributed by the coal industry.

Funding contributions to approved projects are shown in Table 1. Contributions to coal-related research since April 1, 1977 are shown in Figure 1. The distribution of funding contributions for the past two years, and projected for 1986/87, is shown in Figure 2.

TABLE 1 FUNDING CONTRIBUTIONS TO APPROVED PROJECTS (1985/86)

PROJECT	Cumulative to March 31, 1985	April 1, 1985 to March 31, 1986	Projected Future Contributions	Total
Exploration				
Surface Geophysical Coal Exploration	96 915	111 996	124 500	333 411
VLF Geophysical Methods in Coal Exploration	4 426	10 420	Nil	14 846
Potential of Geophysical Techniques for Coal Exploration	Nil	69 470	Nil	69 470
Structural Geometry of Imbricated Thrust Sheets	Nil	22 873	30 127	53 000
Mining				
Coal Mining Research	1 538 123	417 439	Nil	1 955 562
Coal Mining in 2035	Nil	78 682	25 240	103 922
Geotechnical Properties of Overburden	Nil	71 501	Nil	71 501
Ground Movements in Coal Mines	Nil	11 469	14 031	25 500
Preparation and Upgrading				
Coal Preparation Research	4 468 475	224 014	Nil	4 692 489
Coal Beneficiation Process	68 546	153 440	855 000	1 076 986
Agglomeration of Subbituminous Coal	Nil	18 444	31 556	50 000
Preparation Process Yield Losses	Nil	56 000	19 900	75 900
Properties of Thermally Dried Coals	Nil	99 459	45 000	144 459
Combustion				
Prediction of Coal Combustibility	Nil	83 359	304 900	388 259
Combustion of Agglomerated Coal	2 061	22 950	32 250	57 261
IEA Coal Combustion Science	Nil	101 619	327 870	429 489
Combustion Program Development	Nil	31 042	46 375	77 417
Combustion Characteristics of Alberta Coals	Nil	83 066	200 000	283 066
Combustion Process Research	Nil	21 814	125 000	146 814
Smoky DENSECOAL Combustion Tests*	Nil	9 560	Nil	9 560
Conversion				
ENR/ARC Conversion Research	13 791 366**	550 983**	Nil	14 342 349
PYROSOL Process Review	Nil	7 006	Nil	7 006
New Liquefaction Processes	Nil	26 785	198 000	224 785
Liquefaction Process Improvements	Nil	43 114	Nil	43 114
Liquefaction Process Evaluation	Nil	22 053	51 600	73 653
Chemistry of Coal Liquefaction	Nil	72 410	471 000	543 410
Functional Group Analysis of Coal Liquids	Nil	30 515	60 485	91 000
Electrolysis of Coal Slurries	Nil	26 655	86 345	113 000
Isotopic Studies of Co-processing Liquids	Nil	22 082	51 918	74 000

PROJECT	Cumulative to March 31, 1985	April 1, 1985 to March 31, 1986	Projected Future Contributions	Total
Transportation				
Coal Slurry Pipeline Research	265 236	22 717	Nil	287 953
Environment				
Coal Conversion Wastewater Treatment Technology	Nil	17 305	46 695	64 000
Markets				
Fuel Options for Enhanced Oil Recovery	Nil	15 000	Nil	15 000
Conversion from Oil to Coal Water Fuels	Nil	26 093	11 407	37 500
Other				
Coal Technology Information Centre	382 120	189 000	Nil	571 120
CTIC Review	Nil	16 997	Nil	16 997
Technical Information Needs *	Nil	17 011	Nil	17 011
Information for Research Planning	Nil	10 784	41 216	52 000
Devon Coal Research Centre	18 940 072	47 747	Nil	18 987 819
TOTAL	**$ 39 557 340**	**$ 2 862 874**	**$ 3 200 415**	**$ 45 620 629**

** Not A CERRF funded*
*** Expenditures adjusted to reflect audit adjustments to prior years' expenditures*

FIGURE 1: Research Expenditure on Approved Projects, (excluding Devon Coal Research Centre)

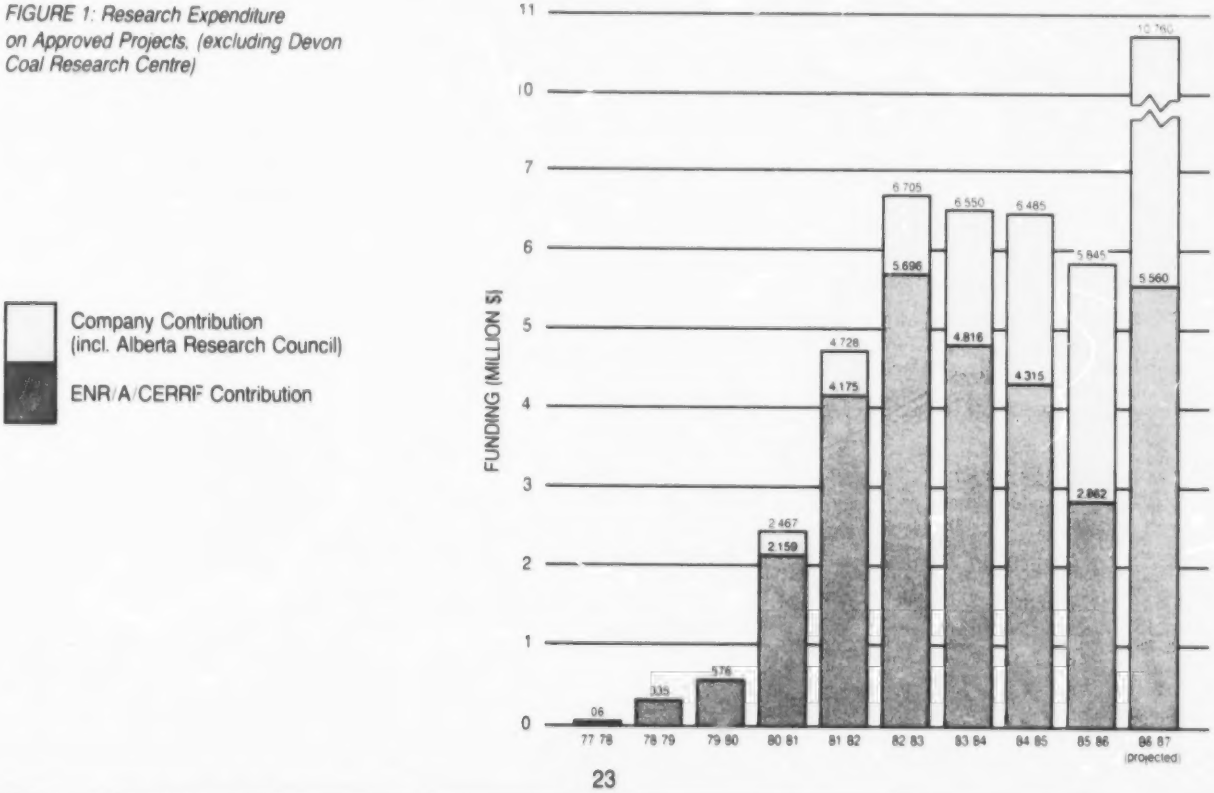
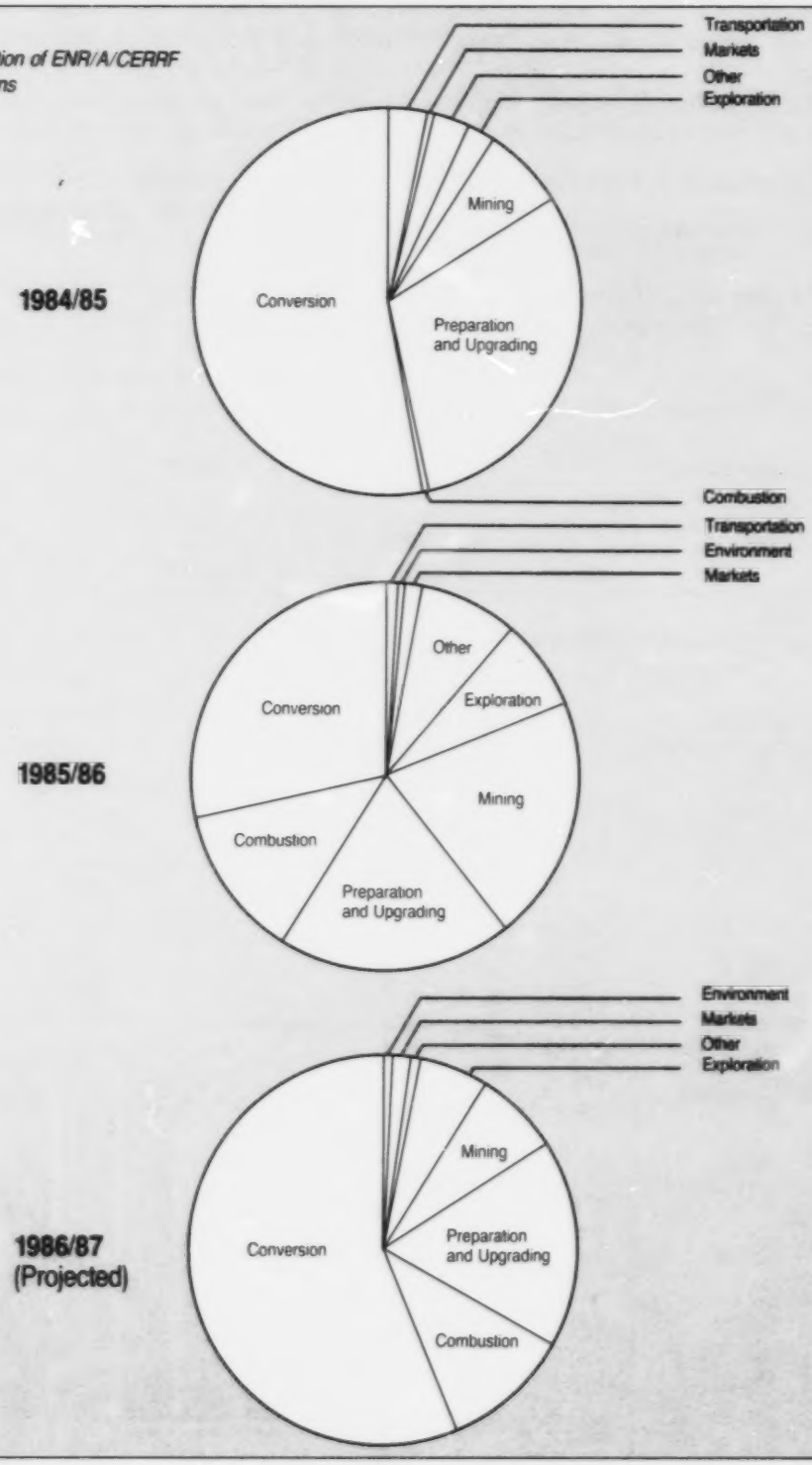


FIGURE 2: Distribution of ENR/A/CERRF Funding Contributions



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For additional copies of this report, contact:
Alberta Office of Coal Research & Technology
2nd Floor, Pacific Plaza
10909 Jasper Avenue
Edmonton, Alberta, T5J 3M8
Telephone: (403) 427-8042